Problem Wk.5.5.1: Modeling the Conrolled/Sensor

Read the handout for Homework Assignment 2.

System Function

Enter the system function $\frac{V_c}{E}$ for the combined sensor/controller system below. Enter the numerator and denominator separately. You must enter them both (if the denominator is empty, enter a "`1`". The numerator and denominator do not need to exactly match our solution, but the ratio must be the same.

You can enter algebraic expressions in "standard" notation; the checker will try to turn your input into a valid Python expression. An example answer is something like:

```
2 (x + 3)
```

If you're having trouble with syntax, you can always type a legal Python expression, fully parenthesized and with all the operators, including `*` and `**`.

A few extra quick notes about syntax:

- These expressions are case-sensitive. `A` is not the same thing as `a`. Remember that, by convention, signals have capital letter names, and samples have lowercase letter names.
- To enter subscripts (e.g. k_s), use an underscore between the variable name and the subscript (e.g. `k_s`).
- To enter greek letters, just type the name of the letter. Note the difference between capital letters and lowercase letters. E.g., `Delta` becomes Δ, whereas `delta` becomes δ.
- Use a capital `R` for the delay operator R.

As an example, here is a list of some of the variables defined in the handout, along with the ASCII representation you should enter to represent each variable in the tutor:

Variable	ASCII
k_s	k_s
k_m	k_m
k_b	k_b
r_m	r_m
k_c	k_c
T	T
Ω_h	Omega_h
Θ_h	Theta_h

Numerator:

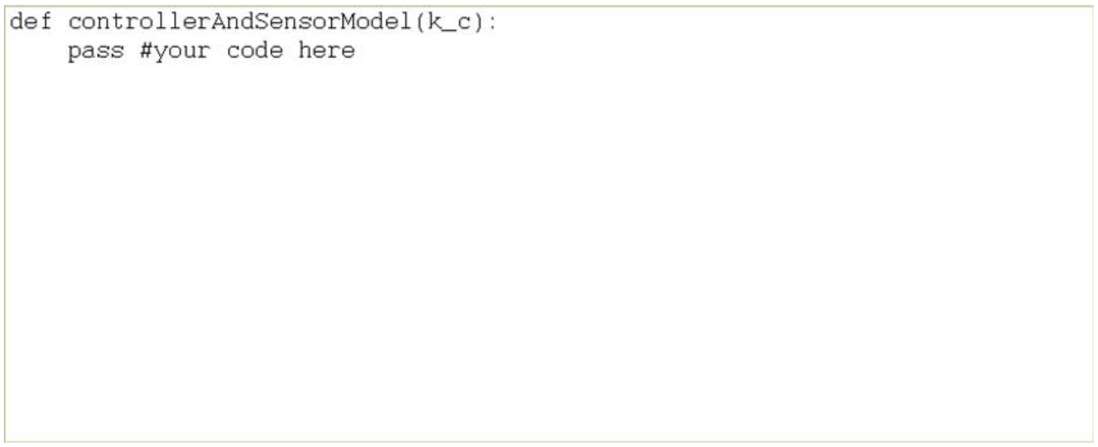
Denominator:

Block Diagram

Upload a PDF file containing your block diagram for this system. Please double-check that your file is a valid PDF before uploading. You will be able to check that the file is correctly uploaded.

Code

Enter your code for `controllerAndSensorModel` below. The global variables defined in `hw2Work.py` can be used in your definition; do not redefine them here. Your code may use functions from the `sf` module, such as `sf.Gain(...)`; no `import` statements should be needed.



```
def controllerAndSensorModel(k_c):
    pass #your code here
```

Problem Wk.5.5.2: Modeling the Plant

Read the handout for Homework Assignment 2.

Integrator System Function

Enter the system function $\frac{\Theta_h}{\Omega_h}$ for the integrator below, in terms of T. Use a capital R for the delay operator R.

Numerator:

Denominator:

Motor System Function

Enter the system function $\frac{\Omega_h}{V_c}$ for the motor below, in terms of k_m, k_b, r_m, and T. Use a capital R for the delay operator R.

Numerator:

Denominator:

Plant System Function

Enter the system function $\frac{\Theta_h}{V_c}$ for the plant below, in terms of k_m, k_b, r_m, and T. Use a capital R for the delay operator R.

Numerator:

Denominator:

Block Diagram

Upload a PDF file containing your block diagram for the plant. **Make sure you have clearly labeled which part corresponds to the motor, and which to the integrator**. Please double-check that your file is a valid PDF before uploading. You will be able to check that the file is correctly uploaded.

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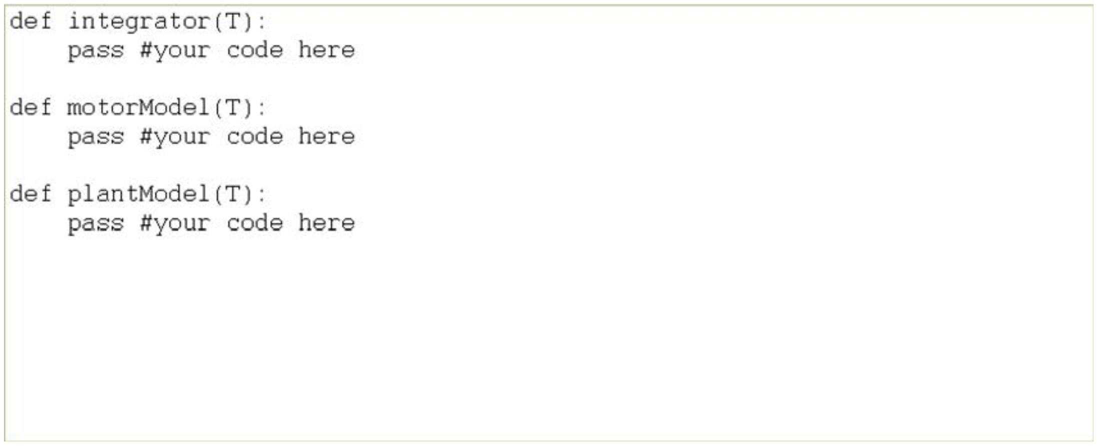
Code

Enter your code for for the plant model below. Include your code for `integrator`, `motorModel`, and `plantModel`. The global variables defined in `hw2Work.py` can be used in your definition; do not use the numerical values in your code, use the variable names. Your code may use functions from the `sf` module, such as `sf.Gain(...)`; no `import` statements should be needed.



```
def integrator(T):
    pass #your code here

def motorModel(T):
    pass #your code here

def plantModel(T):
    pass #your code here
```

Problem Wk.5.5.3: Putting It Together

Read the handout for Homework Assignment 2.

System Function

Enter the system function $\frac{\Theta_h}{\Theta_l}$ for the entire light tracking system below.

Numerator:

Denominator:

Block Diagram

Upload a PDF file containing your block diagram for this system. **Make sure you have labeled all of the signals mentioned in the handout**. Please double-check that your file is a valid PDF before uploading.

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Poles

Enter the poles of the system, as algebraic expressions involving k_c and T, into the boxes below. Assume the following values for constants (the same as in `hw2Work.py`):

Variable	Value
k_s	5 volts/rad
k_m	1000 (rad / sec^2) / Amp
k_b	0.5 volts / (rad / sec)
r_m	20 ohms

If a pole appears n times, enter it into n boxes. If there are more boxes than poles, enter `none` (no quotes) in the remaining boxes.

This question is either marked as entirely correct, or entirely wrong. In order to be marked correct, you must have **all** of the poles correct, and no extra poles entered. This means that you will not see any green checks if you do not have the complete answer, even if part of your answer is correct.

If you need to take the square root of a quantity, you can do so either by using the `sqrt(...)` function, or by raising it to the (1/2) power. For example, enter $\sqrt{3}$ as any of `sqrt(3)`, `3**(0.5)`, or `3**(1/2)`.

Poles:

Code

Enter your code for `lightTrackerModel` below. You may assume that all of the pieces you have already entered (`integrator`, `controllerAndSensorModel`, `motorModel`, `plantModel`), as well as the constants defined in `hw2Work.py`, are defined for you; there is no need to redefine them. Your code may use functions from the `sf` module, such as `sf.Gain(...)`; no `import` statements should be needed.

```
def lightTrackerModel(T,k_c):
    pass #your code here
```

Problem Wk.5.5.4: Analyzing the System

Read the handout for Homework Assignment 2.

Gains

Best Gain

Enter the best value you found for k_c you found for when T = 0.005 seconds. Make sure your answer is accurate to within 0.0001 of the theoretical best gain.

Best value of k_c when T = 0.005 seconds:

Enter the poles associated with these values of k_c and T. If a pole appears n times, enter it into n boxes. If there are more boxes than poles, enter "none" in the remaining boxes.

Rationale

Use the following text box to answer these questions:

- Why must the gain be positive?
- How did you find the best gain?

Regions

Answer the following questions about how the behavior of the system depends on the gain k_c, when $T = 0.005$ If you used empirical methods, make sure your answer is accurate to within 0.0001 of the theoretical best answer.

- For what range of k_c is the system monotonically convergent?

$\_\_\_ < k_c \leq \_\_\_$

- For what range of k_c is the system oscillatory and convergent?
  $\_\_\_ < k_c < \_\_\_$
- What is the lowest positive value of k_c for which the system is unstable?
  k_c = ___

Plots

Upload a single PDF containing plots of the following. Clearly label each plot with the value of k_c used to generate the plot.

- The best non-oscillatory response
- An oscillatory but stable response
- An oscillatory, unstable response

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Effect of T

In the following textbox, answer these questions:

- What happened when you increased/decreased T?
- Why?